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PRESSURE OF THE VAPOR OF WATER.

BY H. A. HAZEN.

ONE of the more important facts needed in meteorology is the pressure of the vapor of water, commonly called "vapor pressure" for short. Until very recently Regnault had obtained the best values for this element. His method was to introduce a capsule of distilled water, from which all air had been expelled, into the vacuum of a barometer and there liberate the water. It is well known that this vapor will diffuse itself and absolutely saturate the space above the mercury. Its pressure will be exactly dependent upon the temperature and can be ascertained approximately by comparing the barometer reading with a perfect barometer. It is easy to see that many elements of inaccuracy are introduced in such an apparatus. Most of these have been eliminated by a most beautiful apparatus, designed and constructed by Prof. C. F. Marvin, of the Weather Bureau. I have made thousands of readings with it, and it is one of the most satisfactory instruments to manipulate I have ever seen. In this, the two barometers are dispensed with, but there are two vertical tubes connected at the bottom and partly filled with mercury. A bulb is attached to one of the tubes, and afterward the air is exhausted and vapor liberated by breaking a capsule of water previously inserted in the bulb. The heights of the mercury columns are read by means of a vernier. I found no difficulty in repeating again and again, and day after day, readings within .03 to .04 of a millimetre (.0012 to .0016 in.). A full description of a perfected apparatus will be found in the Annual Report of the Chief Signal Officer for 1891, pp. 351–383.

In January, 1890, I carried the apparatus with great pains to Northfield, Minn., and there made a series of readings, the results of which were published in the Annual Report of the Chief Signal Officer, 1890, pp. 658–662. Perhaps the most interesting result obtained was a marked difference in vapor pressure when the temperature of the water was different from that of the vapor. This is best shown in a series of comparisons of water at freezing and a portion of the vapor above it at different temperatures, as follows:

Water 32°.									
Vapor Temperature Fahr.	32	42	52	62	72	82	92	102	112
Vapor pressure	4.60	4.57	4.55	4.53	4.50	4.48	4.44	4.39	4.33

Most of the vapor in these experiments was at the temperature of the liquid.

It should be noted, in passing, that Professor Marvin did not obtain any effect of this kind, and in his results it is ignored.

There has just come to hand a very interesting paper, by Prof. Geo. W. A. Kahlbaum, of Basel, Switzerland, in "Archives des Sciences Physiques et Naturelles," Geneva, vol. 31, p. 49. In this paper the author shows very clearly that there is a marked effect depending upon the difference in temperature between the liquid and the vapor above it. The only portion of this investigation needed for our purpose is that relating to the vapor of water. To present the facts in the best possible shape for comparison I have placed in the following table values of vapor pressure at different temperatures by various experimenters. In the first column is the temperature of the vapor in degrees Fahr., and in the succeeding columns the pressure in millimetres of mercury, as observed by Regnault, computed by Broch from Regnault's observations, observed by Kahlbaum, by Professor Marvin, by myself, and as determined by the Royal Society of England, probably from the results of various observers, but this is a mere inference.

VAPOR PRESSURE IN MILLIMETRES AT VARIOUS TEMPERATURES.

(1) Fahr.	(2) Reg.	(3) Broch.	(4) Kahl.	(5) Marvin.	(6) Hazen.	(7) Roy. Soc.
0	1.01	1.14		.97	1.11	1.30
5	1.32	1.44		1.25	1.38	
10	1.72	1.81		1.60	1.72	1.98*
15	2.18	2.25		2.06	2.18	
20	2.78	2.79		2.61	2.75	2.95
25	3.45	3.43		3.31	3.44	
30	4.25	4.22		4.17	4.25	4.37
35	5.17	5.15		[5.24]	5.17	
40	6.29	6.26			6.28	6.38
45	7.60	7.58			7.62	
50	9.16	9.14	9.36		9.15	9.17
55	11.00	10.97	10.97		10.91	
60	13.15	13.22	13.13		13.05	13.11
65	15.68	15.65	15.67		15.59	
70	18.62	18.59	18.47		18.53	18.36
75	22.04	22.01	21.76		21.96	
80	25.99	25.96	25.67		25.88	25.53
85	30.56	30.52	30.51		30.30	
90	35.81	35.76	36.12		35.41	35.05

A comparison of (2) and (3) shows a tendency to error at very low temperatures in the mathematically computed results. I do not see how we can go back of the original record in such case. The values in (4) agree fairly well with those in (2), except at 50°, 70, 75 and 80. It is possible there is a misprint, otherwise there would seem to be some error in the values. It would be very gratifying if we had the results at the lower temperatures. Column (5) gives results which are lower than those in (2), and as the observations were all at temperatures of 70° for some of the vapor, it would seem, according to the law determined by two independent observers, that these values are all too small. Perhaps Regnault's work was done at temperatures of water, or ice, and vapor approximately the same, and, if so, his results may be very nearly correct, so far as this point is concerned. In column (6) all the values are reduced to a common temperature of water and vapor. These agree remarkably with column (2) till we reach 85°, when there is a falling off. It was found rather difficult to manipulate the apparatus at this high temperature, and it is also probable that whatever errors existed in the apparatus were largely increased at these higher temperatures, so that I do not insist upon the absolute accuracy of the results in (6) above 85°. It is a little singular that there should be this rather rapid fall in my values as compared with Regnault's, and I am confident they are not due wholly to errors in (6). There is another point of great interest in this connection. Column (4) is supposed to have this effect entirely eliminated, but that has a very sharp fall as compared with (2) at 70° $-.15^{mm}$, 75° $-.28^{mm}$, 80° $-.32^{mm}$, then a rise at 90° $+.31^{mm}$. It seems very difficult to account for these jumps in (4), and it may be that there is some error